

# State Water Resources Control Board *and*

EPA, Region 9 present:

## STORMS Seminar Series



CA SWRCB, EPA  
March 23, 2016

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## Strategy to Optimize Resource Management of Storm Water (STORMS)

### Mission:

To lead the evolution of storm water management in California by **advancing the perspective that storm water is a valuable resource**, supporting policies for collaborative watershed-level storm water management and pollution prevention, removing obstacles to funding, developing resources, and integrating regulatory and non-regulatory interests.



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Thank you, Dr. Richard  
Luthy!

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Using Graywater and  
Stormwater to Enhance Local  
Water Supplies: An Assessment  
of Risks, Costs, and Benefits

Richard G. Luthy, committee chair

CA SWRCB, EPA  
March 23, 2016

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# Overview

- Study Tasks
- Water Savings Potential
- Water Quality
- Risks
- State of Practice
- Costs & Benefits
- Future Research Needs

## 9 Sponsors

- EPA (OW, ORD, Region 9)
- National Academies' Presidents Fund
- National Science Foundation
- Water Research Foundation
- Water Environment Research Foundation
- WaterReuse Research Foundation
- Los Angeles Department of Water and Power
- City of Madison, Wisconsin
- National Water Research Institute (NWRI)

## Committee Members

- **RICHARD LUTHY**, *Chair*, Stanford University
- **RICHARD ATWATER**, Southern California Water Committee
- **GLEN DAIGGER**, University of Michigan (formerly CH<sub>2</sub>M-Hill)
- **JÖRG DREWES**, Technische Universität München, Germany
- **BENJAMIN GRUMBLES**, Maryland Dept. of the Environment
- **ARPAD HORVATH**, University of California, Berkeley
- **ROBERT PITT**, University of Alabama
- **MARCUS QUIGLEY**, OptiRTC, Boston
- **ROBERT RAUCHER**, Stratus Consulting/Abt Associates
- **SYBIL SHARVELLE**, Colorado State University
- **CLAIRE WELTY**, University of Maryland Baltimore County
- **MARYLYNN YATES**, University of California, Riverside

**Stephanie Johnson**, NRC, study director

Committee held 6 meetings; authored consensus report

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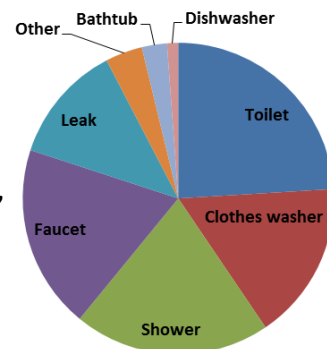
## Definitions

### *Stormwater runoff*

- Water from rainfall or snow measured downstream in a pipe, culvert, or stream shortly after the precipitation event
- Includes runoff captured from rooftops

### *Graywater*

- Wastewater produced from bathroom sinks, showers, bathtubs, clothes washers, and laundry sinks. Derived from residential or commercial buildings.
- Does not include toilet or kitchen water



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## Study Tasks

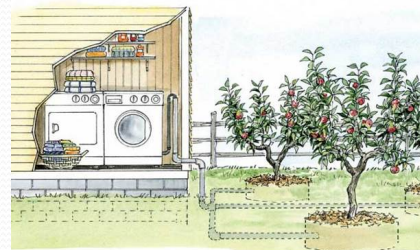
1. **Quantity and suitability.** What is the potential to increase stormwater and graywater use in the U.S., and where would increased practice have the most benefit?
2. **Treatment and storage.** What types of treatment are available and how do these treatment methods compare in terms of cost and energy use?

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## Study Tasks (cont.)

3. **Risks.** What are the human health and environmental risks for various uses?
  4. **Costs and benefits.** What are the costs and benefits of the beneficial use of stormwater and graywater (including non-monetized costs and benefits)?
  5. **Implementation.** What are the legal and regulatory constraints for use of captured stormwater and graywater?
- Related to 1-5, what research is needed?



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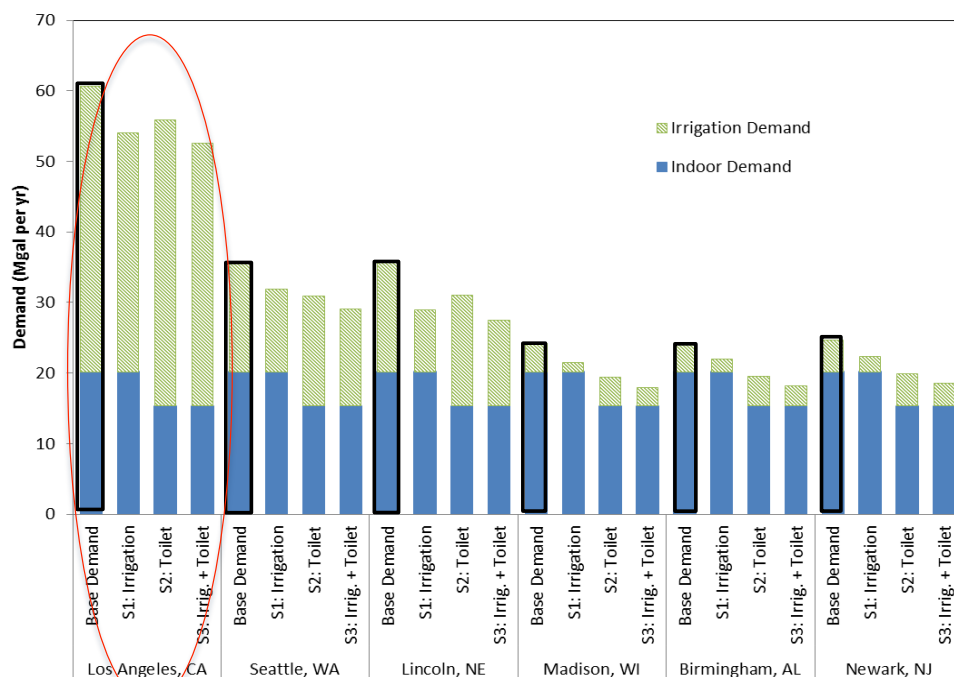
# Original Analysis of Potential Savings

- Analysis of residential stormwater and graywater use:
  - 100 acres, 12 persons per acre
  - Site-specific data: LA, Seattle, Madison, Lincoln, Newark, & Birmingham
  - 1995-1999 rainfall, long-term ET to estimate monthly irrigation needs
  - Graywater assumed U.S. average graywater daily supply
- Scenarios considered:
  - Graywater: whole house and laundry to landscape (irrigation only)
  - Stormwater: roof runoff in 2 rain barrels or 2,200 gal tank
- Calculated potential savings for:
  - Conservation irrigation (barely meet ET) for turfgrass
  - Toilet flushing
  - Irrigation and toilet flushing

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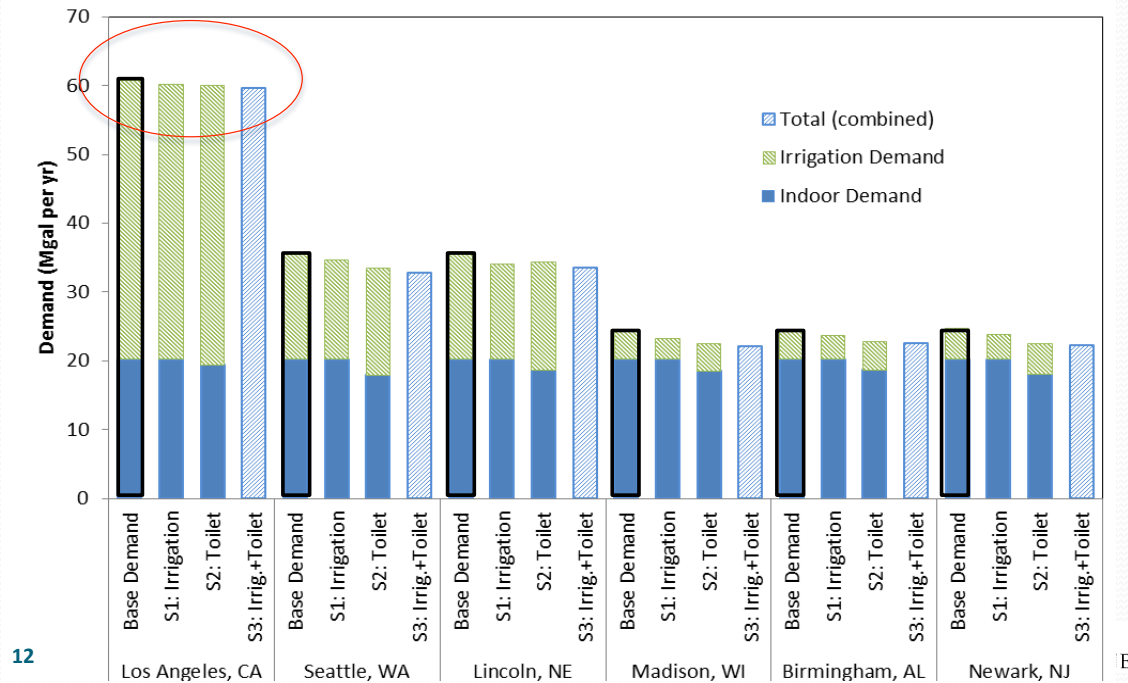
## Potential Household Graywater Savings



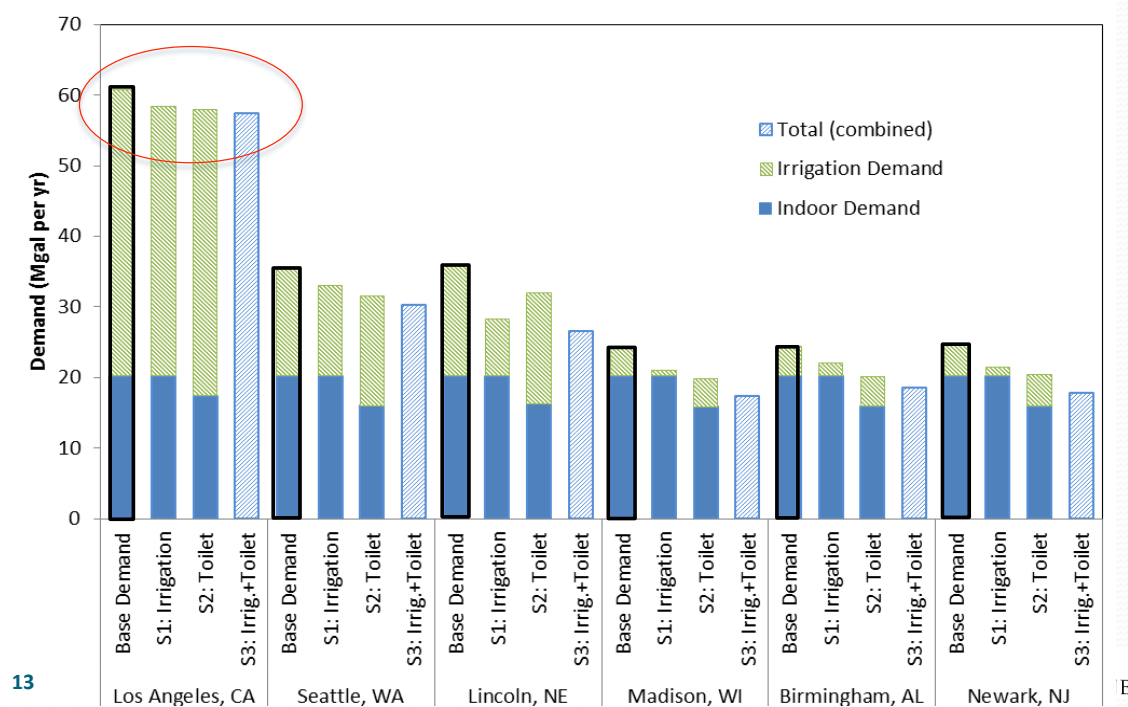
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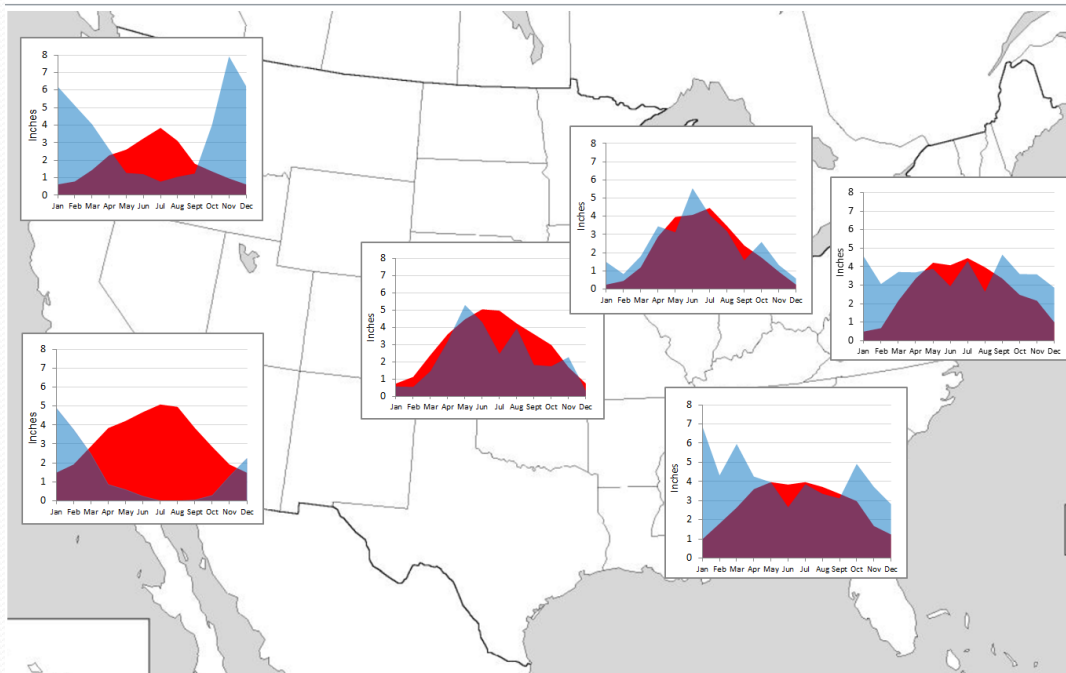
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## Rooftop Capture: Potential Rain Barrel Savings Two 35 gal barrels (70 gal total)



## Rooftop Capture: Potential 2,200 Gal Tank Savings





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Blue=rainfall; red=irrigation demand

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## Water Availability

### Stormwater:

- Dependent on tank size and amount/timing of precipitation relative to demand
- Neighborhood and regional-scale projects can contribute significantly to urban water supplies

### Graywater:

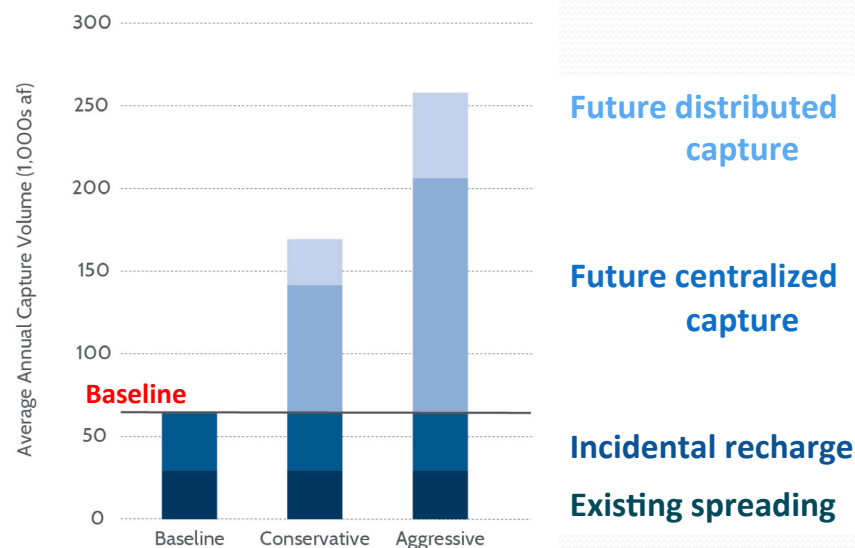
- Substantial potential savings, particularly useful in arid regions

*If water conservation is the objective, strategies to reduce outdoor water use should first be examined.*

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# Urban Stormwater Capture & Recharge



LA's stormwater capture master plan --- an aggressive path *this century* could add nearly 200,000 afy from today's baseline (SWCMP, 2015)

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## Water Quality

- Stormwater :
  - Highly variable over space and time, although related to land use
  - Little is known regarding human pathogens and organic chemicals in stormwater, additional research is needed
- Graywater:
  - Pathogens & organic matter necessitate treatment for uses with human contact



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# Risk

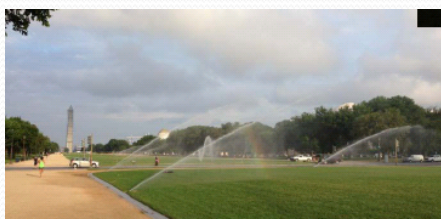


- Risk assessment provides a means to determine “fit-for-purpose” criteria or treatment needs based on exposures
- Pathogens: the most significant acute risks
  - Extremely limited data, which precludes a full assessment of risk, particularly for roof runoff.
- Stormwater recharge poses risks of groundwater contamination and necessitates careful design to minimize those risks

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## Risk: Irrigation Methods



- *Subsurface irrigation*
  - Water is supplied through drip systems (buried or covered by landscape)
- *Surface irrigation*
  - Drip irrigation (no cover)
- *Spray irrigation*

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## DDOE Microbial Risk-based Levels for Stormwater Use Based on Human Exposure Category

Contaminant (µg/L)	Swimming	Direct Human Exposure Category		
		High	Medium	Low
E. coli (CFU/100 mL)	126	1714	4615	50,000
Cryptosporidium (oocytes/L)	NA	0.016	0.033	0.320

## Water Quality: Graywater Use to Flush Toilets

	BOD <sub>5</sub> (mg L <sup>-1</sup> )	TSS (mg L <sup>-1</sup> )	Turbidity (NTU)	Total Coliform (cfu/ 100ml)	E. Coli (cfu/ 100ml)	Disinfection
California	10	10	2	2.2	2.2	0.5 – 2.5 mg/L residual chlorine
New Mexico	30	30	-	-	200	-
Oregon	10	10	-	-	2.2	-
Georgia	-	-	10	500	100	-
Texas	-	-	-	-	20	-
Massachusetts	10	5	2	-	14	-
Wisconsin	200	5	-	-	-	0.1 – 4 mg L <sup>-1</sup> residual chlorine
Colorado	10	10	2	-	2.2	0.5 – 2.5 mg/L residual chlorine
Typical Graywater	80 - 380	54 -280	28-1340	10 <sup>7.2</sup> –10 <sup>8.8</sup>	10 <sup>5.4</sup> –10 <sup>7.2</sup>	N/A

## Roof Runoff: Indoor Use

	Turbidity (NTU)	E. Coli (CFU/100ml)	Total Coliforms (CFU/100ml)
California	10	< 100	-
Texas	-	< 100	< 500
Georgia	-	< 100	< 500

### DDOE high human exposure pathway for stormwater use:

1714 CFU/100 ml

### Graywater Use for Toilet Flushing:

Total Coliforms: 2.2 – 500 CFU/100ml

*E. Coli*: 2.2 – 200 CFU/100ml

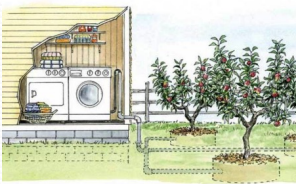

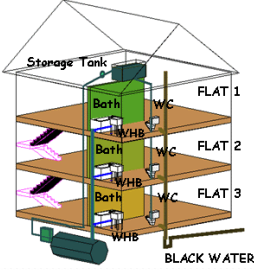
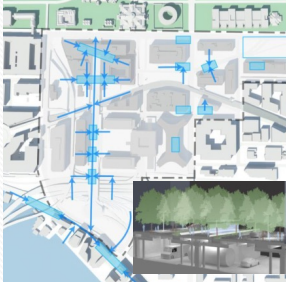


## National Sanitation Foundation 350 Water Quality for Graywater Use for Toilet Flushing

Parameter	Class R <sup>a</sup>		Class C <sup>b</sup>	
	Test Average	Single Sample Maximum	Test Average	Single Sample Maximum
CBOD <sub>5</sub> (mg/l)	10	25	10	25
TSS (mg/l)	10	30	10	30
Turbidity (NTU)	5	10	2	5
<i>E. coli</i> (MPN/100 ml)	14	240	2.2	200
pH (SU)	6.0-9.0		6.0-9.0	
Storage vessel residual chlorine (mg/l)	≥ 0.5 - ≥ 2.5		≥ 0.5 - ≥ 2.5	

<sup>a</sup> Class R: Flows through graywater system are less than 400gpd

<sup>b</sup> Class C: Flows through graywater system are less than 1500gpd

# Risk Changes with Scale

	Graywater	Stormwater
Household		
Neighborhood/Multi-		
Regional		

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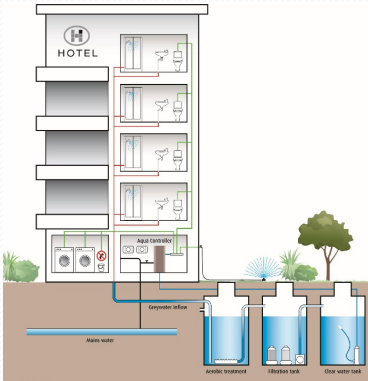
## Graywater Reuse: Consideration of Scale

	Household	Neighborhood/Multi-residential	Commercial and Institutional
Irrigation	<ul style="list-style-type: none"> <li>Drip or subsurface irrigation required, sometimes not practical in grassy areas.</li> </ul>	<ul style="list-style-type: none"> <li>Multi-residential: more graywater is often generated than required for irrigation.</li> <li>Human health risks from untreated graywater are higher than at the household scale.</li> </ul>	<ul style="list-style-type: none"> <li>Graywater generation rates vary widely</li> <li>Often graywater production is not sufficient to meet end use demands,</li> <li>Can be suitable when showers or laundry are on-site (e.g. fitness facilities, hotels, offices with showers, aquatics centers).</li> <li>Hospitals are not appropriate sites for graywater use due to contamination potential.</li> </ul>
Toilet Flushing	<ul style="list-style-type: none"> <li>Treatment is required and systems can be complex for homeowners to maintain.</li> <li>Risk for cross connection and improper maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Graywater volume generated is often suitable for toilet flushing.</li> <li>Maintenance activities can be performed by facilities staff.</li> </ul>	

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# State of Practice: Graywater



- Irrigation at the household scale can be achieved with simple systems
- Reuse for toilet flushing are most appropriate in multi-residential buildings
- Many state graywater treatment standards for toilet flushing are not risk-based or fit-for-purpose
- New developments provide opportunities for rethinking the use of water and waste streams for saving money, energy, & water

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# State of Practice: Stormwater



- The state of practice for cost-effective, safe roof-runoff capture systems are hindered by the lack of data on human pathogens.
- Stormwater infiltration for aquifer recharge is commonly practiced, but designs and regulations in the United States may not be adequately protective of groundwater quality for new systems in urban areas.

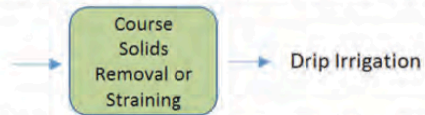


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# Stormwater Treatment Systems

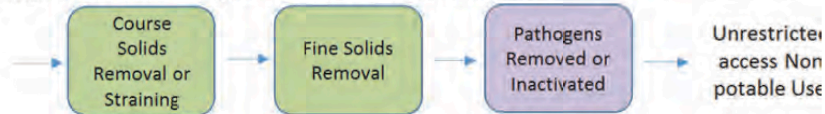
(A) Typical Treatment for Mulch-covered Drip or Subsurface Irrigation



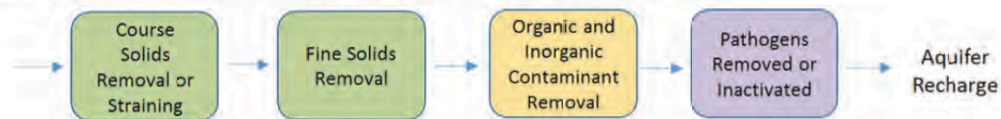
(B) Typical Treatment for Spray Irrigation with Restricted Access



(C) Typical Treatment for Urban Nonpotable Use with Unrestricted Access (e.g., spray irrigation, toilet flushing) or Where Disinfection Is Required



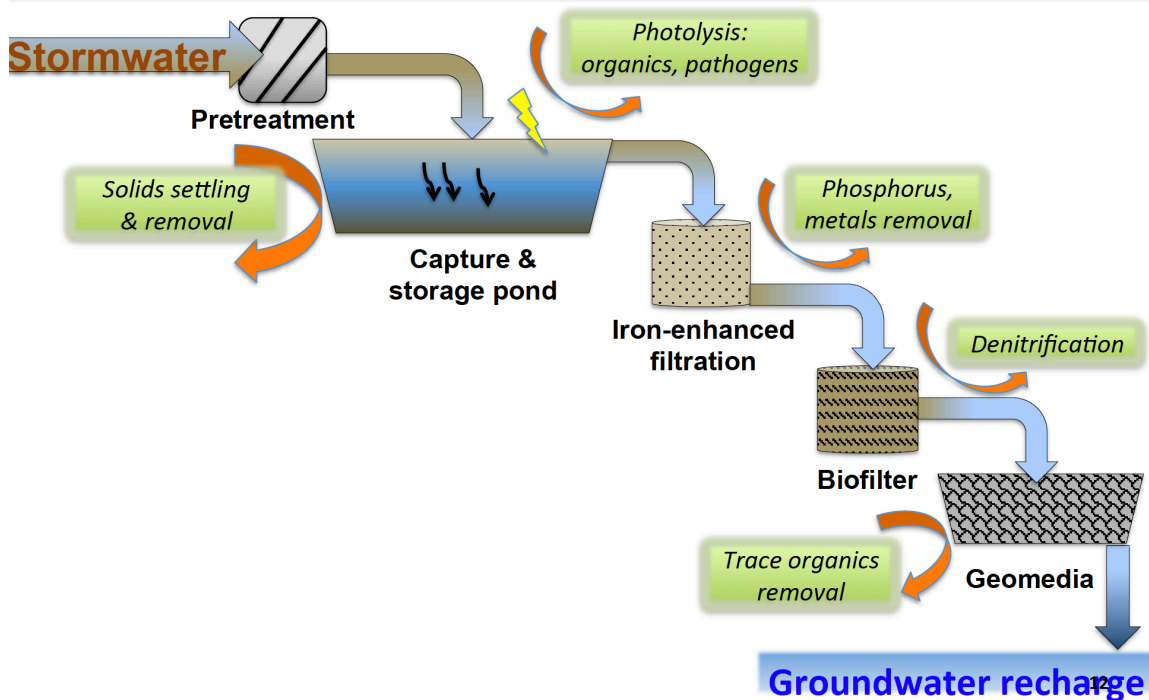
(D) Treatment Concerns for Groundwater Recharge of a Water Supply Aquifer



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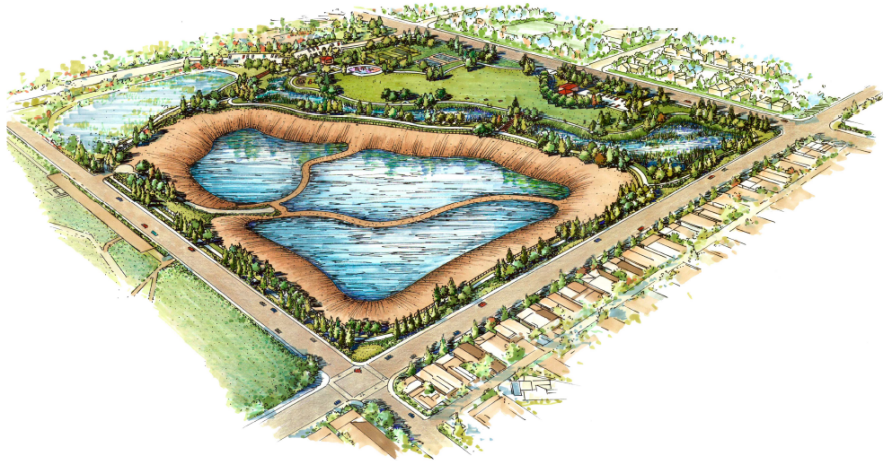
## Stormwater: capture, treatment & recharge



# What might a CTR-system look like?

## Rory M. Shaw Wetlands Park

- Convert 45-acre gravel pit to facility for stormwater retention, treatment, groundwater recharge, habitat & recreation.
- Costs: \$46 mill (\$28 mill for land), \$240,000/year (O&M)
- Volume recharge: 900 AFY



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## State of Practice: Operations

- Operations and maintenance of household and neighborhood graywater and stormwater use systems are not well guided or monitored (e.g., pathogens).
- Many states require that systems meet water quality targets, but ongoing monitoring is not required.
- Online monitoring of surrogate parameters (e.g., residual chlorine, turbidity) should be considered.



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# Costs and Benefits

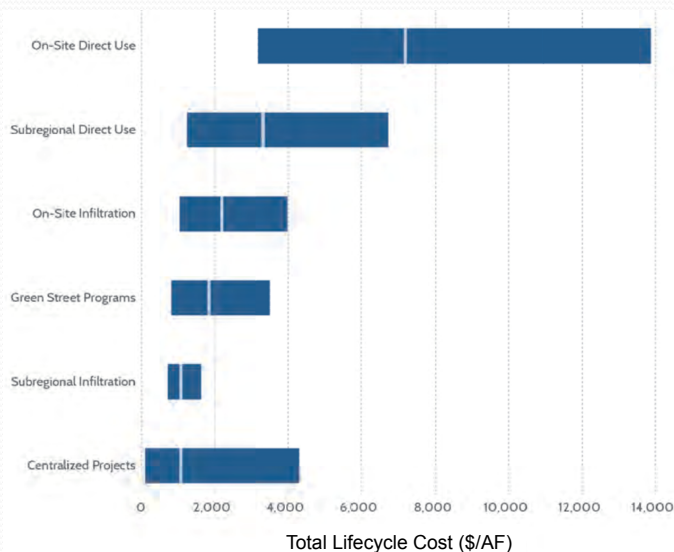
*It is important to recognize the full suite of benefits—as well as the full costs—of graywater and stormwater projects, although it may be challenging to do so.*

- Financial cost data are extremely limited
- Social & environmental costs & benefits rarely monetized
- Energy savings are possible, but data for a sound assessment are lacking.

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## Costs and Benefits (LA, SWCMP, 2015)



- Simple systems can offer reasonable financial payback periods under certain scenarios/climates.
  - However, behavioral factors on water use are poorly understood
- Economies of scale are evident

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# Legal and Regulatory

- In most western states, acquisition of water rights is a requirement for inland large-scale projects and may limit stormwater and graywater projects.
- Substantial variation in on-site regulations at the state level, allowing for varying exposures and risk.
- The lack of authoritative, risk-based guidelines for the design and potential applications of graywater and stormwater in the United States is a major impediment to their expanded use.

# Research Needs

## *Risk and water quality*

1. Assess the occurrence and fate of pathogens in graywater and stormwater
2. Assess the occurrence and fate of chemical contaminants in stormwater
3. Understand the implications of enhanced water conservation on graywater quality and use
4. Develop risk-based water quality guidance for various uses that could serve as a basis to develop standards of practice
5. Develop monitoring technology and strategies to assure compliance with water quality criteria

# Research Needs



## *Treatment technology*

6. Develop treatment systems to meet tailored (fit-for-purpose) water quality objectives across a range of scales
7. Understand the long-term performance and reliability of graywater and stormwater treatment systems (from small to large scales)

## *Infrastructure*

8. Envision opportunities for water- and energy-conserving infrastructure designs in new construction and demonstrate performance
9. Identify strategies to retrofit existing infrastructure for enhanced beneficial use of stormwater

# Research Needs

## *Social science and decision analysis*

10. Understand behavioral impacts on overall water use in the context of graywater and stormwater projects
11. Collect performance data (e.g., cost, energy, water savings, water quality, and other benefits) in support of integrated water supply management, decision making, and refinement of decision tools

## *Policy and regulatory issues*

12. Identify incentives and various regulatory strategies that have proven effective in the implementation of stormwater or graywater systems to conserve water supplies

# Summary

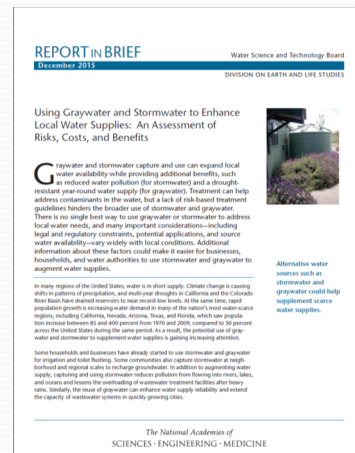
- Graywater and stormwater capture and use can expand local water availability while providing additional benefits.
- Treatment can help address contaminants in the water, but a lack of risk-based treatment guidelines hinders the broader use of stormwater and graywater.
- There is no single best way to use graywater or stormwater to address local water needs
  - many important considerations—including legal and regulatory constraints, potential applications, climate, and source water availability—vary widely with local conditions.
- Research on information about costs, benefits, risks, treatment needs, and behavioral factors would enhance decision making.

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# More Resources

- Full report at <http://www.nap.edu/>
- Additional resources under “Resources” tab:
  - 4-page report in brief
  - Press release
- Final book to be printed this spring



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